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# Determinants of energy consumption function in SAARC countries: Balancing the odds

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ABSTRACT

The objective of the study is to investigate the multivariate energy consumption function for South Asian Association for Regional Cooperation (SAARC) countries (namely, Bangladesh, India, Nepal, Pakistan and Srilanka), particularly, economic growth (GDP), relative prices of energy (REP), foreign direct investment (FDI) and different financial development indicators (i.e., broad money supply, liquid liabilities, domestic credit provided by banking sector and domestic credit to private sector) over a period of 1975–2011. The results reveal that Granger causality running from all other variables to FDI which indicates a strong support for the hypothesis that energy consumption (EC), GDP, REP and FD are important determinants in promoting the FDI both in short- and long-run, in the context of Bangladesh. The results suggest for India indicate that GDP, FDI, REP and FD are useful in explaining the movements of EC in the short-run. Similarly, the Granger causality results indicate that EC, GDP, REP and FD are the important determinants of FDI. In case of Nepal, REP is the only variable whose movements in the short-run determined by movements in the other four variables i.e. GDP, FDI, EC and FD. However, the EC also provide useful information about the variable FD. The results of Pakistan indicate the causal relationship among FDI and EC which supports the "feedback hypothesis" in the short- and long-run. Similarly, both variables i.e., FDI and GDP supports the feedback hypothesis both in the long run and short run, where as FD and EC, FD and REP, FDI and REP and finally REP and GDP supports the feedback hypothesis in the short run. In case of Srilanka, this study did not find any strong support of the causality among the variables either in the short or long run except unidirectional Granger causality running from FD to EC and EC to FDI.



**Contents**



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## 1. Introduction

South Asia is ranked as one of the regions with lowest per capita consumption of Energy particularly in form of electricity despite the fact that region is blessed with enormous energy potential for generating enormous amount of electricity. Presently, South Asian countries are producing electricity less than 50% of their available potential [25]. In 2005, recognizing the pivotal role that energy plays in economic and social development, the 13th South Asian Association for Regional Cooperation (SAARC) Summit approved the establishment of the SAARC Energy Centre (SEC) in Islamabad. The SEC is currently mandated to strengthen its member countries' energy capacities by facilitating energy policy coordination through the establishment of common policies. By enhancing regional capabilities, the SEC is also expected to be a catalyst for economic growth. Under the guidance from the SEC, Bangladesh, India, and Pakistan are now working together to address their own as well as the region's energy issues [11].

In South Asia, progress in regional economic integration has been weak and slow, and investment issues have not yet been included in the process. As a result, the region has not realized its potential to attract FDI inflows associated with regional integration, especially intraregional ones. Since the mid-2000s, strong economic growth in major economies in the sub-region has created momentum for regional integration, and South Asian countries have increasingly realized that regional integration can help them improve the climate for investment and business. The inclusion of an investment agenda in the regional integration process and in particular the creation of a regional investment area can play an important role in this improvement [48].

The key question in energy economics is whether growth factors lead to energy consumption (EC) or whether EC leads to growth factors. Although the causal relationship between EC and growth factors has been widely studied over the last three decades, the empirical evidence is not without controversy [23]. According to Zachariadis [52], p. 1233,

> "There is a rapidly growing literature on the interaction between energy use and economic development, with many analysts drawing policy conclusions on the basis of Granger causality tests that involve only energy and an economic variable".

Çoban and Topcu [13] investigate the relationship between financial development and energy consumption in the EU over the period 1990–2011 by using system-GMM model. No significant relationship is found in the EU27. The empirical results, however, provide strong evidence of the impact of the financial development on energy consumption in the old members. Lee [29] investigates the contributions of foreign direct investment (FDI) net inflows to clean energy use, carbon emissions, and economic growth by using panel data of 19 nations of the G20 from 1971 to 2009. The results indicate that FDI has played an important role in economic growth for the G20 whereas it limits its impact on an increase in CO2 emissions in the economies. Song et al. [42] figure out China's indicators of economic growth and changes in energy consumption brought by technological progress since 1986. Empirical results show that China's high-speed economic growth is still largely dependent on massive energy consumption. China's rapid economic growth should have to maintain reduce energy consumption. China has faced the very problem which should needs to address. Chu and Chang [12] applies bootstrap panel Granger causality to test whether energy consumption promotes economic growth using data from G-6 countries over the period of 1971–2010. The result reveals that nuclear consumption Granger causes economic growth in Japan, the UK, and the US; economic growth Granger causes nuclear consumption in the US; nuclear consumption and economic growth show no causal relation in Canada, France and Germany. Regarding oil consumption-economic growth nexus, there is one-way causality from economic growth to oil consumption only in the US, and that oil consumption does not Granger cause economic growth in G-6 countries except Germany and Japan. Wu et al. [50] adopted data envelopment analysis (DEA) for measuring congestion with undesirable outputs to analyzing congestion of the industry in 31 administrative regions of China. The results show that five regions have congestion in their industry in 2010. Besides, the regions located in the east of the country perform the best in ecological efficiency, followed by regions in central and west China.

Ekholm et al. [15] discuss the implications of financing constraints for future energy and climate scenarios for Sub-Saharan Africa. The results portray the effect of capital cost on technology selection in electricity generation, specifically how limited capital supply decreases investments to capital-intensive zero-emission technologies. As a direct consequence, the emission price required to meet given emission targets is considerably increased when compared to case that disregards the capital constraints. Tang and Shahbaz [43] assess the causal relationship between electricity consumption and real output at the aggregate and sectoral levels in Pakistan by using annual data from 1972 to 2010. The results reval that at the aggregate level, there is unidirectional Granger causality running from electricity consumption to real output in Pakistan while at the sectoral level, electricity consumption Granger-causes real output in the manufacturing and services sectors. However, there is no causal relationship between electricity consumption and real output in the agricultural sector. Solarin and Shahbaz [41] investigate the causal relationship between economic growth, urbanization and electricity consumption in the case of Angola, over the period of 1971–2009. The results in favor of bidirectional causality between electricity consumption and economic growth; and between urbanization and economic growth.

Akhmat and Zaman [2] investigate the causal relationship among nuclear energy consumption, commercial energy consumption and economic growth in selected South Asian countries, over the period of 1975 to 2010. The results reveal that nuclear energy consumption Granger causes economic growth in Nepal and Pakistan; while, oil consumption Granger causes economic growth in Bangladesh, Bhutan, Maldives, Nepal and Srilanka; gas consumption Granger causes economic growth in Bangladesh, Bhutan, India and Maldives; electricity consumption Granger causes economic growth in India and Srilanka, finally, coal consumption Granger causes economic growth in Bangladesh, Bhutan, Nepal and Srilanka. Alam [3] find causality relationships between electric power consumption, foreign direct investment and economic growth for India and Pakistan covering a period of 1975–2008. The results indicate for India shows the long run causalities for electric power consumption and foreign direct investment boosting economic growth, electric power consumption and economic

growth impacting foreign direct investment. For Pakistan, causality was established for foreign direct investment and economic growth inducing electric power consumption in the long run. Ahmed et al. [1] examine the relationship between electricity consumption per capita and real per capita income in the context of Pakistan, over a 34-year period (between 1975 and 2009). The study provides evidence of bi-directional causality between the electricity consumption per capita and real per capita income on one hand; and energy consumption per capita and real per capita income on the other hand as the direction of causality has significant policy implications. Zaman et al. [53] examine the two way causal relationship between energy consumption and development factors in the context of Pakistan over a period of 1980–2009. The result of causality strongly supports the bidirectional relationship between carbon dioxide emission and energy demand and industrialization & energy demand, however, there is a unidirectional causality relationship between the energy demand and population growth. Neither agriculture value addition nor energy demand affects each other.

Shahbaz et al. [38] investigates the relationship between energy consumption and economic growth by incorporating number of growth variables in case of China over the period of 1971–2011. The Granger causality analysis revealed that unidirectional causal relationship running from energy consumption to economic growth. Financial development and energy consumption Granger cause each other. There is bidirectional causality between trade and energy consumption; capital and energy consumption; financial development and economic growth and, international trade and economic growth. Hossain [21] examines the dynamic causal relationship between economic growth, electricity consumption, export values and remittance for the panel of three SAARC countries using the time series data for the period 1976–2009. The result reveals that there is a bidirectional short-run causal relationship between economic growth and export values; however, there is no evidence of long-run causal relationship. Mudakkar et al. [30] investigates the causal relationship between energy consumption (i.e., nuclear energy consumption, electricity power consumption and fossil fuels energy consumption); industrialization (i.e., industrial GDP, beverages and cigarettes); environmental degradation (i.e., carbon dioxide emissions, population density and water resources); resource depletion (i.e., mineral depletion, energy depletion, natural depletion and net forest depletion) and economic growth in Pakistan over a period of 1975–2011. The results infer that there exists unidirectional causality running from nuclear energy to industrial GDP, nuclear energy to water resources; and nuclear energy to carbon dioxide emissions but not vice versa. Similarly, electric power consumption Granger cause agriculture GDP but not other way around, further, there is a bi-directional causality running between electric power consumption to population density in Pakistan. Fossil fuel Granger cause industrial GDP and there is a bidirectional causality running between fossil fuel and population density.

Hossain and Saeki [22] examines the dynamic causal relationships between electricity consumption and economic growth for five different panels (namely high income, upper middle income, lower middle income, low income based on World Bank income classification and global) using time series data from 1960 to 2008. The result reveals that there is bidirectional causality between economic growth and electricity consumption both in the short-run and long-run in high income, upper middle income and global panels. Unidirectional short-run causality is found from economic growth to electricity consumption for lower middle income panel and no causal relationship is found for low income panel. Shahbaz and Lean [35] assess the relationship among energy consumption, financial development, economic growth, industrialization and urbanization in Tunisia from 1971 to 2008. Long-run bidirectional causalities are found between financial development and energy consumption, financial development and industrialization, and industrialization and energy consumption in Tunisia. Zaman et al. [55] identify major macroeconomic factors that enhance energy consumption for Pakistan through the cointegration, error correction model and Granger causality tests over a 32-year time period, i.e., between 1980 and 2011. The empirical results only moderately support the conventional view that energy consumption has significant long-run casual effect on macroeconomic variables in Pakistan. The present study finds evident of unidirectional causality between the commercial energy consumption factors and macroeconomic factors in Pakistan. However, there is some bidirectional causality exist which is running between electricity consumption (EC) and exports, EC to imports, EC to carbon emissions, EC to natural resource depletion (NRD) and EC to wheat. The results conclude that macroeconomic variables tend to positively respond to total primary energy consumption. Shahbaz et al. [40] investigates the relationship between energy (renewable and non-renewable) consumption and economic growth in case of Pakistan over the period of 1972–2011. The results validate the existence of feedback hypotheses between renewable energy consumption and economic growth, non-renewable energy consumption and economic growth, economic growth and capital. Shahbaz et al. [36] examines the linkages among economic growth, energy consumption, financial development, trade openness and $CO_2$ emissions, using quarter data for the period of 1975Q1–2011Q4 in case of Indonesia. The results indicate that economic growth and energy consumption increase $CO_2$ emissions, while financial development and trade openness compact it. The VECM causality analysis has shown the feedback hypothesis between energy consumption and $CO_2$ emissions. Economic growth and $CO_2$ emissions are also interrelated i.e. bidirectional causality. Financial development Granger causes $CO_2$ emissions.

The above discussion confirms a strong linkage between energy consumption and growth factors in selected SAARC countries using secondary data from 1975–2011. The objectives of this study are to empirically investigate four alternative and equal plausible hypothesis i.e.,

- Growth hypothesis: whether the SAARC countries are energy dependent countries?
- Conservation hypothesis: unidirectional causality running towards growth factors to energy consumption but not vice versa in SAARC countries.
- Feedback hypothesis: bidirectional causality running towards energy consumption to growth factors in SAARC countries.
- Neutrality hypothesis: no casual relationship between energy and growth factors in SAARC countries.

The study is organized as follows: after introduction which is provided in Section 1 above, Methodology is presented in Section 2. The estimation and interpretation of results is mentioned in Section 3. Section 4 concludes the study.

## 2. Methodology

### 2.1. Theoretical framework

A framework based upon the theory of energy-growth nexus which is employed in the multivariate context to study the relationship between energy consumption and growth factors in selected SAARC countries. The standard production function with final output ‘Y’ as a function of capital ‘K’; labor ‘L’; and energy ‘E’

reads

$$Y(t) = F[K(t), L(t), E(t)] \tag{1}$$

where "$F$" is a linear homogenous function and '$t$' the time index. Logarithmic differentiation of Eq. (1) yields

$$\hat{Y}(t) = \theta_K \hat{K}(t) + \theta_L \hat{L}(t) + \theta_E \hat{E}(t) \tag{2}$$

The hate denote growth rates, $\theta$s are the weighting factors, and the subscripts related to the input. Eq. (2) is the well-known growth accounting relation between the growth of inputs and the growth of output. In order to show the effects of energy on growth, Bretschger [9] specify 'F' in Eq. (1) i.e.,

$$Y(t) = F(\cdot) = K(t)^{\alpha}[\phi L_Y(t)^{\alpha-1/\sigma} + (1-\phi)E_Y(t)^{\alpha-1/\sigma}]^{(1-\alpha)\alpha/\sigma-1} \tag{3}$$

where $0<\alpha<1$ is the output elasticity of capital, $0<\phi<1$ is a share parameter, $\sigma \geq 0$ denotes the elasticity of substitution between labor and energy in Y-production, and the subscripts label the sector in which the input is used. Eq. (3) demonstrating the different effects of energy use on growth. Based on Eq. (3), this study attempted to include Gross Domestic Product, energy prices, Foreign Direct Investment (FDI) and Financial Development indicators in energy function, in order to manage robust data analysis. Therefore, the consumption function for energy can be written as follows:

$$EC_t = f(GDP_t, REP_t, FDI_t, FD_t) \tag{4}$$

where $EC_t$ is the energy consumption (i.e., kg of oil equivalent per capita); $GDP_t$ is the per capita GDP (current US\$); REP represents relative price of energy to non-energy goods (measured by the ratio of the price index to the GDP deflator, annual %); FDI is Foreign direct investment, net inflows (% of GDP and $ED_t$) is the financial development indicator based on the most commonly used four proxy variables i.e. the ratio of money and qausi money to GDP (M), the ratio of liquid liabilities to GDP (LL), the ratio of domestic credit claims on private sector to GDP (PRI) and the ratio of domestic credit provided by the banking sector to GPD(BC).

When homogeneity is assumed, the energy consumption can also be specified as a function of real income and relative price of energy to non-energy goods as below:

$$EC_t = f\left(\frac{Y_t}{P_{X,t}}, \frac{P_{E,t}}{P_{X,t}}, FD_t\right) \tag{5}$$

With respect to the above energy consumption framework, obviously energy consumption is depended on real income, relative price, and financial development indicators. According to the existing literature, other factors that influence energy consumption include employment, FDI, population and FD [37,44]. In this study, we use the following generic long run energy consumption model i.e.,

$$\ln EC_t = \alpha_0 + \alpha_1 \ln GDP_t + \alpha_2 REP + \alpha_3 \ln FDI + \alpha_4 \ln FD_t + \varepsilon_t \tag{6}$$

where 'ln' represents the natural logarithm.

These variables are selected because of their vital importance to an emerging region like SAARC. For example, the question of whether or not energy conservation policies affect economic activity is of great interest in the international debate on global warming and the reduction of greenhouse gas emissions. Although the causal relationship between energy consumption and economic growth has been widely studied, no consensus regarding this so-called energy consumption-growth nexus has yet been reached [5]. The impact of (rising) energy prices has never received substantial attention from growth economists, possibly because this has been perceived as a short to medium run issue [6]. The importance of financial elements in the energy–growth framework was firstly introduced by Karanfil [28] and was empirically tested by Sadorsky [37]. Sadorsky [37] found that financial development is important to the demand for energy through the impact of increasing the economic efficiency of a country's financial system. Tang and Tan [44] opine that FDI not only affect economic growth, it also influenced the demand for energy, therefore, an influx of FDI will bring in more advanced technologies which in turn lead to economic growth and energy consumption in developing countries.

The coefficient of GDP is expected to be positive as it is generally accepted. That economic growth is a key variable determining energy consumption and thus an increase of GDP would consume more energy. Similarly, the coefficient of relative prices, FDI and financial development is also expected to be positive with the energy consumption as these factors should have to be a significant contributor to energy consumption in SAARC region, the governments should facilitate developing strong local entrepreneurship, create a stable macroeconomic framework as well as improve conditions for productive investments to speed up the process of economic development [54].

### *2.2. Measuring Financial Development (FD) indicators*

As indicated by Tang and Tan [44], the major problem in many empirical studies on FD is the choice of appropriate variables for measuring the level of FD. Certainly all the aforementioned proxy indicators of FD are highly correlated, so the technique of Principle Component Analysis (PCA) is employed to construct a single variable that represents overall development in the financial sector by taking into consideration the four original FD indicators. The PCA approach allows to composite different correlated indicators into one single index that contains most of the useful information from the original dataset. Annual time series data for energy consumption, GDP, relative energy prices, FDI and four proxy indicators of financial development from 1975 to 2011 were collected for five selected countries of SAARC region i.e. Bangladesh, India, Nepal, Pakistan and Srilanka from World Development Indicators which is published by World Bank (2012).

### *2.3. The Granger causality and the Toda-Yamamoto-Dolado-Lutkephol (TYDL) approach*

The most prevalent causality approach is grounded in Granger's [20] work, which builds on earlier research by Weiner [49]. The notion is one of predictability being synonymous with causality, and is based on the idea that a cause cannot come after an effect. We say that 'X' causes 'Y' if relevant available past information allows us to predict 'Y' better than when past information without 'X' is used. Fugarolas et al. [16] argue that though cointegration refers to equilibrium in the long-run and causality to short-run precedence both notions are in fact linked: as long as an equilibrium relationship exists in the long-run between a pair of series, there must be some Granger causation in at least one direction between them to provide necessary dynamics. Nevertheless, it turns out that there is weakness in this two step causality approach. According to Giles and Mirza [17], this methodology calls for pre-testing unit roots and cointegration before causality testing and the results may suffer from size distortions and inference biases leading to an over rejection of the non-causal null hypothesis. Therefore, there is risk in using Granger causality tests in levels or in difference VAR systems or even in ECMs (see, [45,32], and [56]). Nuisance parameters and non-standard distributions enter the limit theory when either of the required rank conditions is not satisfied in the VECM or the Johansen–Juselius route (see, [46,47], for more details). Following these studies referred here, the multi-step procedure testing causality conditional on the estimation of a unit root, a cointegration rank and cointegration vectors as generally used by previous studies in the Indian context may suffer from severe pre-test biases.

**Table 1**
Principle component analysis to construct an index of FD.

| Component 1 | Bangladesh | India | Nepal | Pakistan | Srilanka |
|---|---|---|---|---|---|
| Eigenvalue | 3.9539 | 3.7116 | 3.8015 | 2.4443 | 3.1406 |
| Variance Prop. | 0.9885 | 0.9279 | 0.9504 | 0.6111 | 0.7851 |
| FD variables | Vector 1 | Vector 1 | Vector 1 | Vector 1 | Vector 1 |
| **Eigenvector 1** | | | | | |
| MM | −0.5018 | −0.5109 | −0.5089 | −0.5923 | −0.5402 |
| LL | −0.5006 | −0.4961 | −0.4805 | −0.4886 | −0.5334 |
| DBI | −0.5007 | −0.4806 | −0.5096 | −0.3584 | −0.4123 |
| DPI | −0.4969 | −0.5118 | −0.5004 | −0.5310 | −0.5037 |

We employ TYDL Granger causality test which is a simple procedure requiring the estimation of an “augmented” or “over fitted” VAR that is applicable irrespective of the degree of integration or co integration present in the system. It uses a modified Wald (MWALD) test to test for restrictions on the parameters of the VAR(p) model. This test has an asymptotic chi-squared distribution with k degrees of freedom in the limit when a VAR [k+dmax] is estimated (where dmax is the maximal order of integration for the series in the system). The following steps are involved in implementing this procedure. The first step includes determination of the non-stationarity properties and the maximal order of integration (denoted as dmax in the system). In this regard, the Augmented Ducky Filler unit root test (with intercept) is conducted at 5% level of significance. The second step is to determine the co integration relationship among the time series variables having same order of integration. The Johansen and Juselius's test for co integration relationship with maximum eigen-value statistic is conducted at 5% level of significance which tests the null hypothesis of ‘$r$’ cointegrating relations against the alternative of ‘$r+1$’ cointegrating relations. The test statistic for ‘$T$’ number of observations is computed as:

$$LR(\lambda_{\max}) = -T\log(1-\lambda_{r+1})$$

For $r=0, 1, 2,\ldots, k-1$.

The third step is to identify true lag length ($k$) of the VAR system using some suitable information criterion (or criteria). The standard vector auto regression (VAR) model implemented in this study is as follows:

$$Z_t = \Phi D_t + \sum_{j=1}^{p-1} \Gamma_j Z_{t-j} + \vartheta_{t'}$$

where $\vartheta_t$ is the residual term, $Z_t$ is a vector of endogenous variables$EC_t = f(GDP_t, REP_t, FDI_t, FD_t)$ and $\mathbf{\Gamma}_1, \mathbf{\Gamma}_2\ldots\mathbf{\Gamma}_j$ are the $5\times5$ matrices of unknown parameters. $D_t$ is the deterministic vector (e.g. having constant and exogenous variables) while $\mathbf{\Phi}$ is a matrix of parameters of the deterministic vector.

The optimal lag order is determined according to different criteria like sequential modified LR test statistic, Schwarz information criterion, Akaike information criterion, Final Prediction Error criterion and Hannan-Quinn information criterion. The next step is to check the stability of the model. The autocorrelation LM test up to the lag 12 is conducted in this regard. The unrestricted level VARL (k+dmax) is then estimated using some suitable estimation method (usually the SUR or Seemingly Unrelated Regressions technique). The last step is to apply standard Wald tests to the first k VAR coefficient matrix only in order to conduct inference on Granger causality while the coefficient matrices of the last dmax lagged vectors in the model are ignored. As shown by Toda and Yamamoto [45] it is enough to add extra and redundant lags in estimating the parameters of the structure to ensure the standard asymptotic properties of the Wald statistic which maintains its usual limiting [chi square] distribution. Therefore, the TYDL enables the proposed MWALD statistic to test linear or nonlinear restrictions on these k coefficient matrices using the standard asymptotic theory [16]. The study undertaken by Giles and Mirza [17] also shows that this augmented lags method performs consistently well over a wide range of systems including near-integrated, stationary and mixed integrated and stationary systems; cases for which the pre-testing approaches tended to over detect causality [18,19].

**Table 2**
Order of integration by using ADF unit root test at 5% level of significance.

| Countries | EC | GDP | REP | FDI | FD |
|---|---|---|---|---|---|
| Bangladesh | I (I) | I (I) | I (0) | I (I) | I (I) |
| India | I (1) | I (2) | I (1) | I (1) | I (2) |
| Nepal | I (1) | I (2) | I (0) | I (1) | I (1) |
| Pakistan | I (1) | I (1) | I (0) | I (1) | I (0) |
| Srilanka | I (1) | I (2) | I (1) | I (0) | I (1) |

## 3. Results

### 3.1. Results of principle component analysis

In the first step of the estimation process, the study constructs the FD indicator based on the four proxy variables. Table 1 represents the results of principle component analysis using FD indicators for five different countries. It is clear that the first principle component (PCA1) is the best principle component, as in case of Bangladesh, Eigen value reveal that the PCA1 explains about 99% of the standardized variance. In case of India, PCA1 explains 93% of the variation, 95% in case of Nepal, 61% in case of Pakistan and 79% in case of Srilanka. Thus the most useful information of original data set is extracted from the first principle component for all different countries. So we only extract one principle component. The individual contributions of MM, LL, DBI and DPI to standardised variance of PCA 1 are used as weights to construct an index for FD. i.e. for Bangladesh (25.09, 25.03, 25.03 and 24.85%) are used as weights to construct an index for FD, for India (25.55, 24.81, 24.04 and 25.60%) are used are used as weights to construct an index for FD, for Srilanka (27.15,26.81, 20.72 and 25.32%)are used as weights to construct FD index, for Pakistan (30.06, 24.80, 18.19 and 26.95%) are used as weights to construct FD index and finally for Nepal (25.45, 24.03, 25.49 and 25.03%) are used as weights for MM, LL, DBI and DPI to construct FD index respectively.

### 3.2. Unit root test results for the integration properties of the data series

In the second step of the estimation process, the study examines the stationarity properties of the data series. In stationary time series, shocks will be temporary and over the time their effects will decay as the series revert to their long run mean values. The present study employs the Augmented Dickey-Fuller (ADF) test with intercept only, to test the presence of unit roots (that is non-stationarity) of the individual series. The ADF Test results are shown in Table 2.

The results indicate that majority of the time series for five different countries are non-stationary, when the variables are defined at levels with constant. While in case of ‘REP’ for Bangladesh, Nepal and Pakistan, the null hypothesis of unit root defined at levels can be rejected at 5% level of significance indicating the stationary time series i.e. I(0). Similarly, time series representing financial development index of Pakistan and Foreign Direct Investment of Srilanka during 1975–2011 is stationary at levels. However, the energy consumption for all five different

**Table 3**
VAR lag order selection.

| | Bangladesh | India | Nepal | Pakistan | Srilanka |
|---|---|---|---|---|---|
| **Lag order** | 3 | 3 | 3 | 3 | 1 |

**Table 4**
Unrestricted cointegration rank test results (Maximum Eigenvalue).

| Countries | Hypothesized no. of CE(s) | Eigenvalue | Max-Eigen statistic | 0.05 Critical value | Prob.[a] |
|---|---|---|---|---|---|
| Bangladesh | None[b] | 0.552380 | 28.13334 | 27.58434 | 0.0425 |
| India | None | 0.358800 | 15.55448 | 21.13162 | 0.2519 |
| Nepal | None | 0.373670 | 16.37571 | 21.13162 | 0.2037 |
| Pakistan | None[b] | 0.453585 | 21.15316 | 21.13162 | 0.0497 |
| | At most 1[b] | 0.350432 | 15.10066 | 14.26460 | 0.0368 |
| Srilanka | None | 0.366489 | 15.97673 | 21.13162 | 0.2262 |

[a] MacKinnon–Haug–Michelis (1999) *p*-values.
[b] Denotes rejection of the hypothesis at the 0.05 level.

countries, become stationary when the series are differenced once, the null hypothesis of unit root can be rejected after first differencing at 5% level of significance. This indicates that the variables are integrated of order 1 i.e. I(1). Similarly, Foreign Direct Investment for all countries except Srilanka is integrated of order 1. The GDP of Bangladesh and Pakistan, 'REP' in case of India and Srilanka and financial development index for Bangladesh, Nepal and Srilanka also become stationary when the series are differenced once i.e. I(1).order of differencing at 5% level of significance. Therefore, we conclude that GDP for India, Nepal and Srilanka are the variables integrated of order 2 i.e. I (2). Similar is the case with financial development index of India. However, in case of GDP for India, Nepal and Srilanka, the series becomes stationary only after second difference.

### 3.3. Determination of optimal lag order in the VAR system

The next step in our analysis is to determine the optimal lag order in the VAR system. Considering that we have annual data we experimented with maximum lag order of 3 and employed all the popular selection criteria. These are sequential modified LR test statistic, Schwarz information criterion, Akaike information criterion, Final Prediction Error criterion and Hannan-Quinn information criterion. We accept the judgment based on what majority of the criteria suggested. Table 3 indicates that the optimal lag order determined for Bangladesh, India, Nepal and Pakistan is $k=3$. However, in case of Srilanka the optimal lag order is $k=1$.

### 3.4. Estimation of the VAR system and stability tests

Following the results of the previous sections, we first estimate the VAR(3) system using Electricity consumption, GPD, Inflation, FDI and FD as endogenous variables and constant as an exogenous variable for the whole sample period (1975–2011) of Bangladesh, India, Nepal and Pakistan.VAR(1) system is estimated in case of Srilanka. Next we run the autocorrelation LM test to check the stability of the estimated systems. The result validates that in selected SAARC countries the autocorrelations among the residuals up to the lag 12 are insignificant. This implies that the fitted systems are tenable.

**Table 5**
Granger causality results using MWALD test.

| Countries | Chi-square | df | Prob. |
|---|---|---|---|
| **BANGLADESH** | | | |
| FDI does not Granger causes GDP | 10.89543 | 3 | 0.0123 |
| GDP does not Granger causes FDI | 34.89575 | 3 | 0.0000 |
| FD does not Granger causes GDP | 8.717871 | 3 | 0.0333 |
| REP does not Granger causes GDP | 9.685564 | 3 | 0.0214 |
| EC does not Granger causes FDI | 26.37920 | 3 | 0.0000 |
| REP does not Granger causes FDI | 19.82243 | 3 | 0.0002 |
| FD does not Granger causes FDI | 11.57425 | 3 | 0.0090 |
| **INDIA** | | | |
| GDP does not Granger causes EC | 36.15927 | 3 | 0.0000 |
| EC does not Granger causes GDP | 8.436539 | 3 | 0.0378 |
| FDI does not Granger causes EC | 14.32979 | 3 | 0.0025 |
| EC does not Granger causes FDI | 6.946807 | 3 | 0.0736 |
| FD does not Granger causes EC | 7.257468 | 3 | 0.0641 |
| REP does not Granger causes EC | 9.039069 | 3 | 0.0288 |
| GDP does not Granger causes FDI | 189.3805 | 3 | 0.0000 |
| REP does not Granger causes FDI | 11.20170 | 3 | 0.0107 |
| FD does not Granger causes FDI | 24.13180 | 3 | 0.0000 |
| **NEPAL** | | | |
| FDI does not Granger causes REP | 12.37340 | 3 | 0.0062 |
| REP does not Granger causes FDI | 7.440987 | 3 | 0.0591 |
| FD does not Granger causes REP | 7.359645 | 3 | 0.0613 |
| REP does not Granger causes FD | 9.315609 | 3 | 0.0254 |
| EC does not Granger causes REP | 10.04900 | 3 | 0.0182 |
| GDP does not Granger causes REP | 6.876556 | 3 | 0.0759 |
| EC does not Granger causes FD | 12.60840 | 3 | 0.0056 |
| **PAKISTAN** | | | |
| FDI does not Granger causes EC | 9.377971 | 3 | 0.0247 |
| EC does not Granger causes FDI | 7.932398 | 3 | 0.0474 |
| FD does not Granger causes EC | 9.730131 | 3 | 0.0210 |
| EC does not Granger causes FD | 22.01236 | 3 | 0.0001 |
| REP does not Granger causes GDP | 6.970478 | 3 | 0.0728 |
| GDP does not Granger causes REP | 20.53002 | 3 | 0.0001 |
| FDI does not Granger causes GDP | 7.250961 | 3 | 0.0643 |
| GDP does not Granger causes FDI | 13.37695 | 3 | 0.0039 |
| FD does not Granger causes REP | 7.751221 | 3 | 0.0514 |
| REP does not Granger causes FD | 21.38491 | 3 | 0.0001 |
| FDI does not Granger causes REP | 12.60886 | 3 | 0.0056 |
| REP does not Granger causes FDI | 30.52944 | 3 | 0.0000 |
| FD does not Granger causes FDI | 12.33340 | 3 | 0.0063 |
| FDI does not Granger causes FD | 21.74689 | 3 | 0.0001 |
| EC does not Granger causes REP | 11.14284 | 3 | 0.0110 |
| GDP does not Granger causes FD | 20.22070 | 3 | 0.0002 |
| GDP does not Granger causes EC | 11.99044 | 3 | 0.0074 |
| **SRILANKA** | | | |
| FD does not Granger causes EC | 5.781955 | 1 | 0.0162 |
| EC does not Granger causes FDI | 5.529882 | 1 | 0.0187 |

### 3.5. Unrestricted level VARL (k+dmax) and the results of modified WALD test

The unrestricted level VARL (k+dmax) is then estimated, where 'dmax' denotes the maximum order of integration. In case of Bangladesh and Pakistan, VARL $(3+1)$ is estimated where fourth lagged values of endogenous variables are considered as exogenous variables, whereas in case of India and Nepal, VARL$(3+2)$ is estimated, since the maximum order of integration is 2. Finally for Srilanka, VARL$(1+2)$ is estimated with 2nd and 3rd lagged values of endogenous variables as exogenous variables. Table 4 shows the results of unrestricted cointegration rank test where Bangladesh has one cointegration equation, Pakistan has two cointegration equations and remaining India, Nepal and Srilanka has no long-run relationship between the variables.

Next we apply standard Wald tests to the first 'k' VAR coefficient matrix only in order to conduct inference on Granger causality. The results of MWALD test showing significant relationships are shown in Table 5.

Table 5 shows the results of Granger causality by using MWALD test. In case of Bangladesh, the Granger causality running between FDI and GDP which is significant at 5% level of significance indicating bidirectional causal relationship between FDI and GDP. This cross checks the cointegration results too. The causality running from FD and REP towards GDP is also significant providing evidence of FD-led growth and REP-led growth hypotheses in Bangladesh. In contrast, the EC does not Granger causes GDP, REP and FD but only impact FDI. That is, movements in EC help explain successive FDI movements. However, the Granger causality running from FD to FDI is also significant even at 1% level explaining that the movements in FD do add explanatory power of lagged FDI in explaining successive FDI values. The presence of the cointegrating relation among EC, GDP, FD and FDI also indicates the long-run relationship among the variables. Thus we conclude that for Bangladesh, the granger causality running from all other variables to FDI is significant which indicates a strong support for the hypothesis that EC, GDP, REP and FD are important determinants in promoting the FDI both in short and long run. Although in case of India, there exists no cointegrating relationship among the variables integrated of same order, however, the Granger causality test indicates some significant causal relationships. For example, the Granger causality running between GDP and EC is significant at 5% level of significance indicating bidirectional causal relationship between GDP and EC. This implies that EC and GDP are jointly determined and affected at the same time [27,51]. Similarly, the Granger causality between EC and FDI is bidirectional at 10% level of significance. However, the Granger causality running from FD and REP to EC is significant at 5% level of significance indicating unidirectional relationship. This indicates that the movements in FD and REP can help explain EC movements. Similarly, the Granger causality running from GDP, REP and FD to FDI is unidirectional at 5% level of significance. Thus we can conclude that in case of India, all the four variables i.e. GDP, FDI, Inflation and FD are useful in explaining the movements of EC in the short run. Similarly, the Granger causality test results indicate that EC, GDP, Inflation and FD are the important determinants of FDI. In case of Nepal, there exists bidirectional causal relationship between FDI and REP. Similarly, the Granger causality running between FD and REP is significant at 5% level of significance. However, the Granger causality running from EC to REP and FD indicates unidirectional causal relationship at 5% level of significance, whereas the causality running from GDP to REP is significant at 10% level of significance. This indicates that in case of Nepal, REP is the variable whose movements in the short run can be determined by movements in the other four variables i.e. GDP, FDI, EC and FD. However, the EC can also provide useful information about the variable FD. In case of Pakistan, some interesting causal relationships appear. For example, the Granger causality running between FDI and EC is significant at 5%level of significance indicating bidirectional causal relationship between FDI and EC. Similarly, there exists bidirectional causal relationship between FD and EC, FDI and REP and between FD and FDI at 5% level of significance, whereas Granger causality between FDI and GDP, FD and REP and between REP & GDP exists at 10% level of significance. The cointegration results also indicate that there exists two cointegrating equations between EC, GDP and FDI which establishes the long run relationship among the variables. The unidirectional Granger causality running from GDP to FD and EC is significant at 5% level of significance, indicating that economic growth can be useful in explaining the movement of financial development and energy Consumption. Thus in case of Pakistan, we conclude that the causal relationship among FDI and EC supports the "feedback hypothesis" in the short and long run. This provides an insight that FDI and EC are jointly determined and affected together. Similarly the variables FDI and GDP supports the feedback hypothesis both in the long run and short run, whereas FD and EC, FD and REP, FDI and REP and finally REP & GDP supports the feedback hypothesis in the short run. However, in case of Srilanka we do not find any strong support of the Causality among the variables in the short or long run except that there exists unidirectional Granger causality running from FD to EC and EC to FDI at 5% level of significance.

The implications of the present study suggest that an energy conservation policy would not lead to any adverse side-effects on growth factors in SAARC countries, whereas energy policy in the case of energy consumption should be adopted in such a way that, energy stimulates economic growth, such growth factors would lead to expand growth opportunities in the SAARC countries.

## 4. Conclusion

This study investigates the causal relationship between energy consumption and growth factors in SAARC countries, by applying techniques of Granger causality and the Toda-Yamamoto-Dolado-Lutkephol (TYDL) approach to find the causal directions between the variables. Principle component approach is used on financial development (FD) indicators, allows us to composite different FD indicators into one single index that contains most of the useful information from the original data set. The results infer that energy consumption Granger cause growth factors either accepted 'growth hypothesis'; 'conservation hypothesis'; 'feedback hypothesis' and the 'neutrality hypothesis' in different SAARC countries. The following conclusions has been emerged with this analysis i.e.,

- The direction of causality between energy and its determinants are highly relevant for policy makers [24].
- The 'growth hypothesis' suggests that energy consumption is a crucial component in growth, directly or indirectly as a complement to capital and labor as input factors of production. Hence, a decrease in energy consumption causes a decrease in real GDP [5]. In this case, the SAARC countries are called 'energy dependent' and energy conservation policies may be implemented with adverse effects on growth factors.
- The 'conservation hypothesis' claims that policies directed towards lower energy consumption in SAARC countries may have little or no adverse impact on growth determinants. This hypothesis is based on a uni-directional causal relationship running from growth factors to energy consumption [7].
- The 'feedback hypothesis' correspond with the bi-directional causality, which argues that energy consumption and growth factors affect each other simultaneously [14]. In this case, SAARC policy makers especially, should take into account the feedback effect of growth factors on energy consumption by implementing regulations to reduce energy use. Additionally, growth factors should be decoupled from energy consumption to avoid a negative impact on economic development resulting from a reduction of energy use [34].
- Finally, the 'neutrality hypothesis' indicates that reducing energy consumption does not affect growth factors or vice versa [31]. Hence, energy conservation policies would not have any impact on growth factors in SAARC region.

The implications of the study are that energy conservation policy would not lead to any side-effects on growth factors in SAARC countries. However, an energy growth policy should be adopted in such a way that it stimulates growth in the economies and thus expands employment opportunities [4]. In order to

achieve rapid economic growth, SAARC members' state should adopt a policy of energy sector development on priority basis. Therefore, there is need to build new dams, installation of wind power plant and tidal energy projects to expand the energy production capacity [33]. The promotion of appropriate structural policies aiming at attracting foreign direct investment can induce conservation and efficient energy use without obstructing economic growth [10]. In SAARC countries, the promotion of foreign direct investment is essential for socio-economic development which towards a more efficiency-orientated and less resource-depleting economies. Regarding the energy consumption, to promote economic growth, the policy should be focused on price level of the electric energy or, directly, on its demand side [39]. In this case, low price level or high demand can promote SAARC's economic growth.

Banking system may encourage investments in energy efficient technology by offering interest discounts and including carbon related conditions in their financial products such as business vehicle and investment real estate term loans. Hence, a set of practical policies and incentives that promote more low-carbon finance is an important part of building up SAARC's resource-conserving society [8]. Emphasis should be placed on investing in renewable energy sources and adopt other energy savings methods including energy mix and mitigation options in the long run [26].

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